Are There Levels Out There?

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Everything in philosophy seems to come in levels. There are levels of organization, levels of abstraction, levels of being, levels of explanation, levels of complexity, levels of analysis… and the list goes on. For example, the British emergentists such as Samuel Alexander and C. Lloyd Morgan believed that there are several levels of existence, where phenomena or properties of higher levels emerge from lower levels (life emerges from the chemical level, mind emerges from the biological level, and so on). Nonreductive physicalists such as Jerry Fodor argue that higher-level sciences do not reduce to lower-level sciences, while reductionists want to reduce everything to the fundamental physical level.

Also scientists like to talk of levels, at least when they are in a philosophical or theoretical mode. Psychologists and cognitive scientists often speak of the behavioral level, the psychological level, the level of the brain, the cellular level, and so on. In evolutionary biology, there is debate concerning the possibility that natural selection happens at various levels: the level of the gene, the level of the cell, the level of the organism, the level of the species, and so on. The protein structure is often described in terms of four levels of organization: amino acid sequences, sub-structures, three-dimensional structures, and the structure of the whole folded protein.

But are there really levels in nature? Do "levels" have a substantial role in scientific theories and explanations, or philosophical analyses?

In this essay, I will argue that the answer to both questions is negative. However, as a first caveat, it should be clear from the above examples that the term 'level' can mean very different things in different contexts. Here my aim is to critically analyze just one specific (and important) notion of levels: levels of organization. Although I believe a similar analysis can be applied to other notions of levels, I will not try to argue for it here. As a second caveat, I focus here on levels in the life sciences. I do not believe that the prospects for levels are any better in the physical or social sciences, but that issue is beyond the scope of this essay.

By levels of organization I mean levels that are based on part-whole relations: simply put, there are wholes at higher levels and their parts at lower levels. As an example, consider a human being. One can analyze a human being at various levels of organization: As a part in a social group, as a biological organism, as complex system composed of cells, at the level of the molecules that make up those cells, at the level of atoms, and finally, at the fundamental level of elementary particles, where a reductionist hopes to find the fundamental explanations, entities, and theories, from which all the rest follows. Thus, we have six levels of organization: social groups, (multicellular) living things, cells, molecules, atoms, and elementary particles. The entities at each level are components of the entities at the next higher level.

This rough picture of levels of organization was proposed by Oppenheim and Putnam in their extremely influential paper "The Unity of Science as a Working Hypothesis" [1], and when philosophers and scientists think of levels of organization or the levels of nature, I would guess that they usually have some version or refinement of this picture in mind. There might be large variation in the exact levels and their number, but the basic picture of levels of organization that cut across nature and are based on part-whole relations is both wide-spread and very intuitive.

Unfortunately, it is also thoroughly problematic, as several philosophers have pointed out (see, e.g., [2] [3]). The essence of the problem is that the nature is too complex for a neat levels-hierarchy: There is a whole range of things that are not easily placed on any level in a simple Oppenheim & Putnam style hierarchy. Consider entities such as organelles, axons, silicon chips, glaciers, books, hurricanes, and so on. Organelles, for example, seem to fit neither on the level of cells (because they are not cells, but rather components of cells) nor on the level of molecules (because they are not molecules). One might add an intermediate level of "organelles" to the hierarchy, but if this is done every time a type of entity does not fit on a level, the result will be hundreds or thousands of levels. The problem is that there is enormous variety and complexity in nature, so if we want to account for everything within one single levels-hierarchy, that hierarchy will not be a neat and appealing layer-cake, but an unintuitive and monstrously complicated construct.

Thus, instead of trying to fit everything into one picture, it is immensely more plausible to think of levels as local: there may be one set of levels in the retina of a carp, a different set in the pancreas of a human, and yet different levels in the white truffle. This is also the guiding idea of the "levels of mechanisms" approach proposed by Bill Bechtel and Carl Craver [2] [4] [5], which is arguably the best account of levels of organization in the literature.

As the title indicates, levels of mechanisms are defined in the context of the "new mechanism" that is popular in contemporary philosophy of science. Levels of mechanisms are based on component-mechanism relations: there are behaving mechanisms at higher levels and their components or working parts at lower levels. That is, at the higher level we have a mechanism that is performing some function, and at the lower level we have the working parts that contribute to the operation of the mechanism. This two-level picture can be expanded into a multilevel hierarchy, when we include the possibility that a working part of a mechanism can be a mechanism itself: the components of that "nested" mechanism then form another level, which is two levels lower than the mechanism as a whole. This process can be iterated as many times as necessary.

Levels of mechanisms are defined only for the mechanism of interest, and do not extend horizontally across nature or even across the whole system under study. For example, there is a certain levels-hierarchy in the human respiratory mechanism, and a different levels-hierarchy in the light transduction mechanism in the retina, and it does not make sense to compare the level of things that are in different mechanisms.

The paradigmatic example given by Craver [2] is the spatial memory mechanism in the hippocampus (of a mouse), where he identifies four levels: the level of spatial memory, the level of spatial map formation, the cellular-electrophysiological level, and the molecular level. In this hierarchy, entities at each lower level are active components in the higher-level mechanism. For example, an NMDA receptor at the molecular level is a component of the LTP mechanism at the cellular level, and the LTP mechanism is in turn a component of the hippocampal mechanism of memory consolidation (at the level of spatial map formation). The hippocampal mechanism of memory consolidation then contributes to the overall mechanism at the level of spatial memory, which is the highest level and includes things such as the mouse performing behavioral tasks (e.g., navigating a water maze).

Bechtel and Craver argue that this local and case-specific approach to levels is sufficient for analyzing issues such as reduction and top-down causation, and that it captures the organization of nature and the talk of levels in science more accurately than alternative (and more global) accounts. I agree that making levels local in this way is a step in the right direction. However, in a closer look, it is questionable whether the levels of mechanisms are levels at all.

According to this account, only things that are in a component-mechanism relation can be at higher or lower levels with respect to one another, and only the (direct or immediate) components of a mechanism are at the same level [2] [4]. One implication of this is that entities that belong to two different mechanisms cannot be at the same level, even if they are exactly the same kinds of entities. For example, glutamate receptors in the retinal mechanism of light transduction and the glutamate receptors in the hippocampal mechanism of spatial memory are not at the same level. This might still be palatable, but it gets worse: Even two entities of the same kind that are in the *same* mechanism are often not at the same level. Since only the direct working parts of a mechanism are at the same level, the components of two different submechanisms can no longer be at the same level. For example, if we have two different types of cells in a mechanism, and they both have glutamate receptors, those glutamate receptors are not at the same mechanistic level.

This also implies that there is no single “molecular level” in the spatial memory mechanism, but instead several molecular levels that do not connect into one level. Each type of cell, or perhaps even each component of a cell, has its own molecular level that consists of the molecules that contribute to that submechanism. When we consider a different submechanism (of the same cell or a different cell), that submechanism has a distinct molecular level, and the molecules of each submechanism are not at the same level with respect to each other.

Thus, as an account of levels, the mechanistic approach suffers from a complete lack of generality. In fact, one could argue that the “levels” of Bechtel and Craver are not levels at all, at least not in any interesting sense. They are simply sets of (direct) components of a mechanism. Bechtel and Craver are certainly correct when they point out that it is often very natural and fruitful to analyze complex (biological) systems as mechanisms that have working parts, and often those working parts can be seen as mechanisms themselves that have working parts of their own, and so on. However, why should we think of these compositional hierarchies as “levels”? It is more accurate and unambiguous to describe them simply in terms of components and mechanisms, especially since the term ‘level’ brings along unwanted intuitions, such that there is a single molecular level in the mechanism.

It is often claimed, also by Bechtel and Craver, that levels are “ubiquitous” or “prevalent” in the life sciences [5] [6]. However, it is far from clear whether this is actually the case, at least when it comes to research papers. A full-text search in the *Journal of Neuroscience* shows that the term “cellular level” appears in less than 3.5% of the articles published in the last ten years. The results for terms such as “molecular level” or “level of organization” are even lower. A similar search for *Cell* reveals a slightly higher result, “molecular level” being the most commonly named level (5-10%, depending on the exact paramters), but this is still far from ubiquitous. Of course, these results are only suggestive, but I think it is fair to say that claims about the ubiquity and importance of levels in science are in need of more evidence and support.

In sum, levels of mechanisms are hardly levels at all, and levels are not at all that common in scientific papers. Is there any hope then for finding a substantial and scientifically relevant sense in which there are levels of organization? I think there remain two approaches that may lead to interesting results. The first of these is based on William Wimsatt’s insightful work on levels (which I cannot discuss here in more detail, see [7] for more). One of his most interesting ideas is that levels can be thought of as local maxima or peaks of regularity and predictability when plotted against a size scale. What this means is that, for example, if there is a “level of molecules”, we should find a peak of regularity and predictability at the size scale of molecules (as opposed to slightly smaller or larger size scales). The main problem with this approach is that it is far from clear how we could measure regularity and predictability [2]. One option would be to evaluate the amount of (causal) explanatory generalizations found at each scale, but that would be a daunting task in itself. In general, although Wimsatt has provided an interesting guiding idea or a starting point, until it is developed in more detail, we have to remain agnostic concerning the existence of levels in this sense.

Another possibility would be to understand levels in terms of the typical or paradigmatic entities that occupy a level. For example, it could be argued that there is a cellular-synaptic level in the brain, which includes everything that is or sufficiently resembles a neuron or a synapse. At the molecular level, the paradigmatic entity would be a molecule (perhaps a neurotransmitter), and everything that is or sufficiently resembles a molecule would belong to that level. Similarly, the levels of organization in protein structure could be understood in terms of the paradigmatic structures at each level. Levels in this sense could be local in the sense that they are restricted to the system or organism of interest, and non-exhaustive in the sense that not everything in a system needs to belong to a level. I think this approach might be worth developing in more detail, but it is best seen as an approach that may be heuristically useful, but will not result in any clear-cut or robust levels.

This brings me to the next point. Even if it turns out there is no sense in which the term 'level' picks out a distinct and natural category, it is unnecessary to ask for levels to be eliminated from science and philosophy. I believe that levels-talk is relatively harmless, and can even be heuristically useful, as long as it is understood to be noncommittal and non-technical, and not even intended to refer to any robust or well-defined category. A natural place for this kind of non-technical levels-talk is in introductions and discussions, where levels also most commonly appear in scientific texts. In contexts such as these, the ambiguity and the lack of specific referent for the term makes little difference.

For example, in the classic textbook *Principles of Neural Science*, Eric Kandel presents the following claim in a section titled "Nerve Cells Differ Most at the Molecular Level": "because the nervous system has so many cell types and variations at the molecular level, it is susceptible to more diseases (psychiatric as well as neurological) than any other organ of the body'' [8]. In this example, the point that Kandel is making is so general that the ambiguity of the expression "molecular level" is harmless. Furthermore, the point can be reformulated without any loss of meaning (in fact, more precisely) in non-level terms: the reformulated statement could be, for example, that the nervous system is susceptible to more diseases than other organs because there is more variation in the molecular composition of nerve cells than in the molecular composition of other kinds of cells.

Similar considerations apply to philosophy. Consider the common claim (which also Bechtel and Craver make) that we need explanations or theories at several different levels and not just at the physical level. The non-reductive thrust of this general claim comes across regardless of what the exact meaning of 'levels' is - the ambiguity (or lack of precise referent) does little harm here. If pressed or if necessary, one can also reformulate or specify the claim without using levels-terminology, for example claiming that we need explanations and theories at various scales, or of various kinds, or throughout compositional hierarchies.

However, in contexts where the term 'level' is used in a technical sense and plays a substantial role, it is potentially misleading and harmful. As a case in point, Craver and Bechtel's [5] account of top-down causation relies on the technical notion of "levels of mechanisms" (which I have discussed above). However, throughout the article Craver and Bechtel slip into thinking of levels in some broader and more intuitive sense, for example in these passages: "There are no causal interactions beyond those at a level", (p. 561) "all of the causal relations are intralevel" (p. 562). Since very few things are at a same level in the technical sense of levels of mechanisms, these claims imply that very few things causally interact, which makes little sense. What Craver and Bechtel really want to say (I think) is that there is no interlevel causation in the sense of causation from a mechanism to the components of that same mechanism, or vice versa. This would have been much clearer if they had simply talked of mechanistic composition instead of levels [see [9] for a more in-depth analysis of this issue).

I believe that this point applies quite generally: for the sake of clarity and in order to avoid wrong intuitions, it is better to avoid 'levels' and to use more specific and well-defined terms whenever anything of importance turns on the exact meaning of the term. As I have argued elsewhere [10], in many situations (such as discussions of top-down causation) it is better to replace levels with either scales or compositional relations. Probably the most important scales in the life sciences are the size scale (how big or small objects are) and the time scale (the rate at which processes occur). What I mean by scale here simply the idea that we measure a certain property (such as size or rate) and then arrange things on a scale of that property. Thus, for example, big things are higher on the size scale than small things. In contrast to levels, scales are relatively unproblematic. Regarding composition, I believe that the analysis of mechanistic composition (mechanisms and their direct components) provided by Bechtel and Craver is useful, once we get rid of the term 'levels' and the wrong intuitions it brings along. Further notions that one can use to analyze the organization of biological systems include control variables, collective variables, sufficient parameters, and aggregativity, to name just a few.

In conclusion, talk of levels should be taken to be noncommittal or heuristic. As a technical term, 'level' is problematic and potentially harmful, so it is better to avoid it and look for alternatives: there are no levels out there.

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